CrIS/ATMS Retrievals Using an AIRS Science Team Version 6-like Retrieval Algorithm

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NASA GSFC Sounder Research Team (SRT)

NASA Sounder Science Team Meeting
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Background

This research is a continuation of research previously supported by the NASA NPP Project and now being done under the recently funded NPP Science Team proposal "CrIS/ATMS Retrievals Using an AIRS Science Team Version 6-like Retrieval Algorithm."

The following presentation is an exact copy of the presentation I gave at the NOAA 2014 STAR JPSS Science Team Annual Meeting in May 2014. Now that the NPP Sounder Discipline Team has been selected, our research plans also include interaction and co-ordination with the NPP Sounder Discipline Lead, Chris Barnet, and as well as other NPP Sounder Discipline Team members.

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2014 STAR JPSS Science Teams Annual Meeting
College Park, MD

May 14, 2014

Background (Cont.)

The AIRS Science Team Version 6 retrieval algorithm is currently producing very high quality level-3 Climate Data Records (CDRs) from AIRS that will be critical for understanding climate processes. All products have their own QC flags based on thresholds of error estimates. CDRs include all cases passing AIRS Climate QC, which provides best spatial coverage. AIRS CDRs should eventually cover the period September 2002 through at least 2020.

CrIS/ATMS is the only scheduled follow on to AIRS/AMSU. This research is being done to address the question of how well CrIS/ATMS can be counted on to adequately continue AIRS/AMSU CDRs beyond 2020.

We believe the best results will be obtained if CrIS/ATMS is analyzed using an AIRS Version 6–like retrieval algorithm

NOAA is currently generating CrIS/ATMS products using 2 algorithms: IDPS and NUCAPS. The NUCAPS algorithm is thought to give superior products. We are investigating the CDR capabilities of the NUCAPS algorithm as well.

SRT Research Using CrIS/ATMS

Approach

Analyze CrIS/ATMS using methodology as closely as possible to AIRS Version 6

SRT CrIS/ATMS Version 5.70 is otherwise analogous to AIRS/AMSU Version 6 but uses a regression based guess instead of a Neural-Net guess

Like AIRS Version 6, CrIS/ATMS Version 5.70 uses only shortwave CrIS window channels to determine surface skin temperature T_s, and uses only shortwave CO_2 channels to determine tropospheric $T(p)$

- Using only shortwave window channels and shortwave tropospheric sounding channels allows for better soundings under harder cloud conditions

We have recently obtained CrIS/ATMS Neural-Net coefficients from Bill Blackwell, but they have not yet been successfully implemented at SRT

We plan to optimize and run Version 6-like CrIS/ATMS retrievals when the CrIS/ATMS Neural-Net capability is functioning properly

NOAA Unique CrIS/ATMS Processing System (NUCAPS)

NUCAPS is based on earlier AIRS Science Team retrieval algorithms and produces most products generated by AIRS Version 6.

Possible limitations of NUCAPS with regard to generation of optimal CDRs:

- Channels used and QC methodology are not up to date with AIRS Version 6
- NUCAPS does not use a Neural-Net guess
  - Use of a Neural-Net guess improved AIRS Version 6 temperature profiles considerably
- NUCAPS appears to have only a single product independent QC flag and does not generate level-3 products
  - We have evaluated NUCAPS level-2 products and generated level-3 products using the single NUCAPS QC flag

We have been told that product dependent QC flags can be generated for NUCAPS. We plan to meet with Antonia Gambacorta and co-workers as to how to properly generate NUCAPS level-3 products.

Comparisons Shown

Results are shown for December 2013 for T_s and *T(p)*

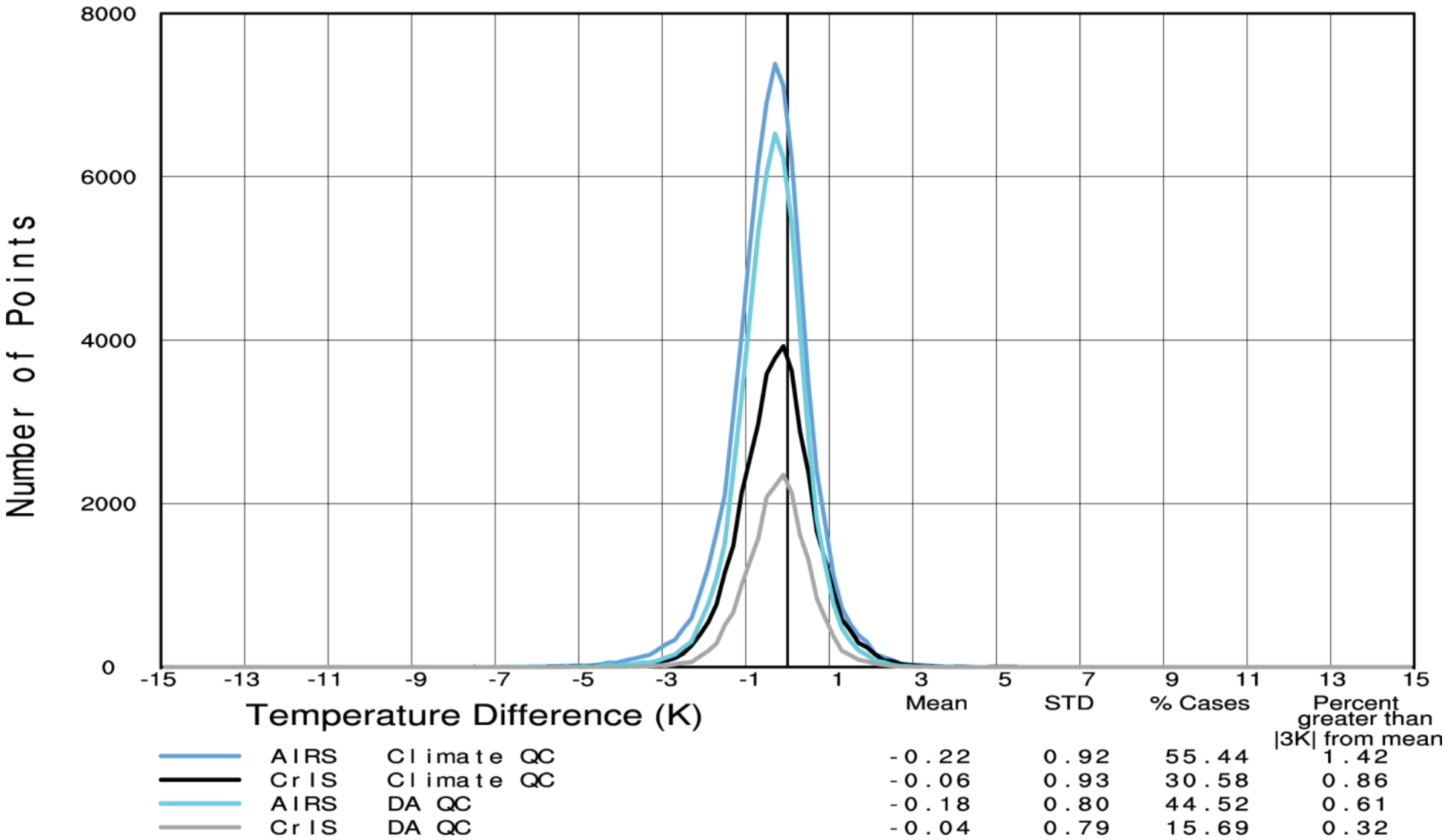
- First comparisons show level-2 AIRS/AMSU Version 6 (called AIRS) and CrIS/ATMS Version 5.70 (called CrIS) results using both tight Data Assimilation (DA) QC, which provides the highest accuracy, and looser Climate QC thresholds which provide excellent spatial coverage while maintaining good accuracy. Achieving AIRS/AMSU Version 6 quality results is our goal for CrIS/ATMS, especially from the level-3 CDR perspective

- Second comparisons show level-2 and level-3 AIRS, CrIS, and NUCAPS CrIS/ATMS (called NUCAPS) products

  AIRS and CrIS level-3 products use their product dependent Climate QC flags

  NUCAPS level-3 products use the NUCAPS single QC flag

Surface Skin Temperature Difference from ECMWF (K)
December 4, 2013 Daytime and Nighttime
50°N to 50°S Non-Frozen Ocean

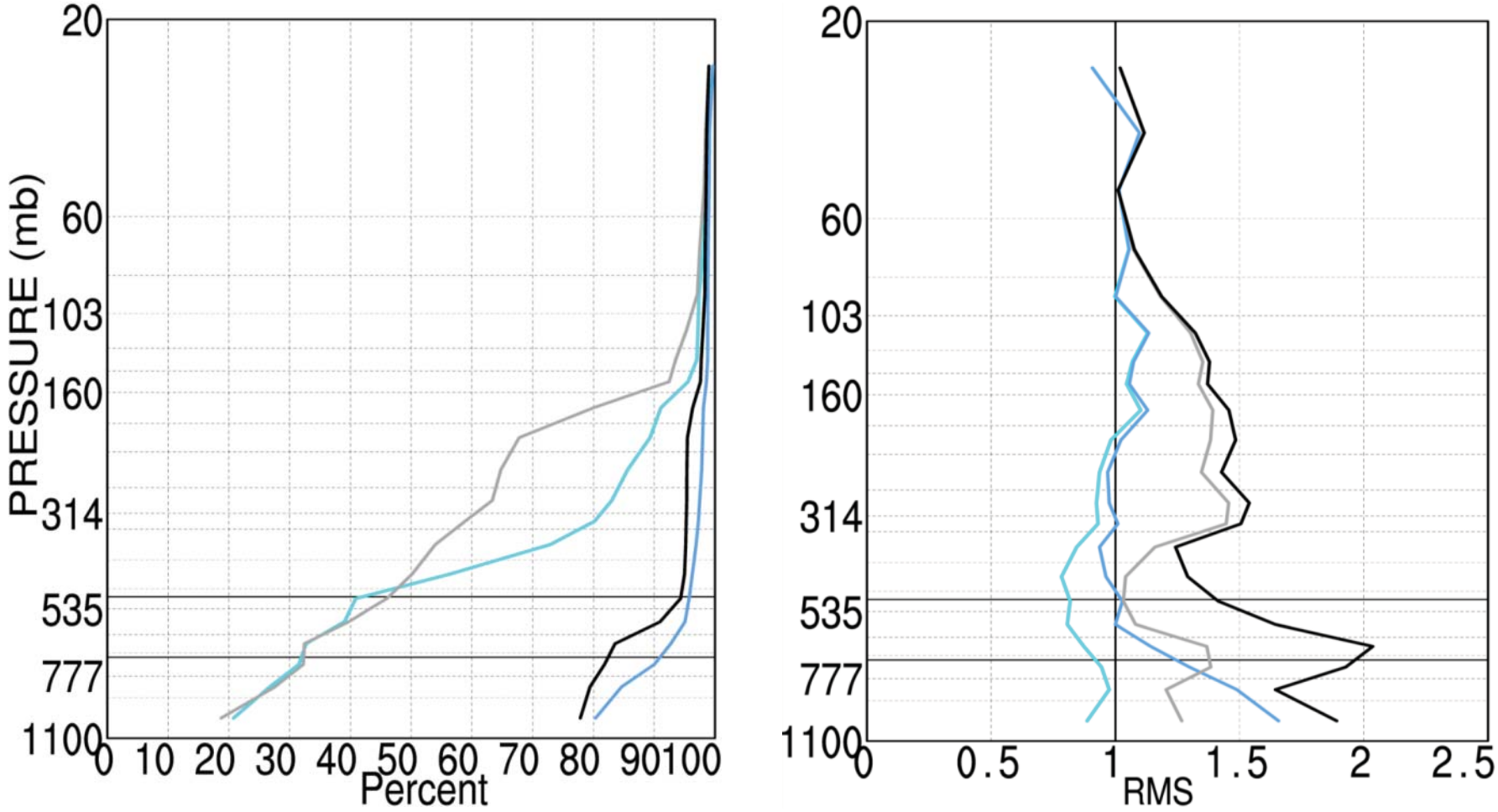


QC'd CrIS SSTs are reasonably good but QC'd AIRS SSTs are much better as a function of yield. CrIS with Climate QC has good error statistics, but has a much smaller yield and poorer accuracy than AIRS with DA QC.

Global Temperature Profile December 4, 2013

Percent of All Cases Accepted

RMS 1 km Layer Mean Difference (K) from ECMWF

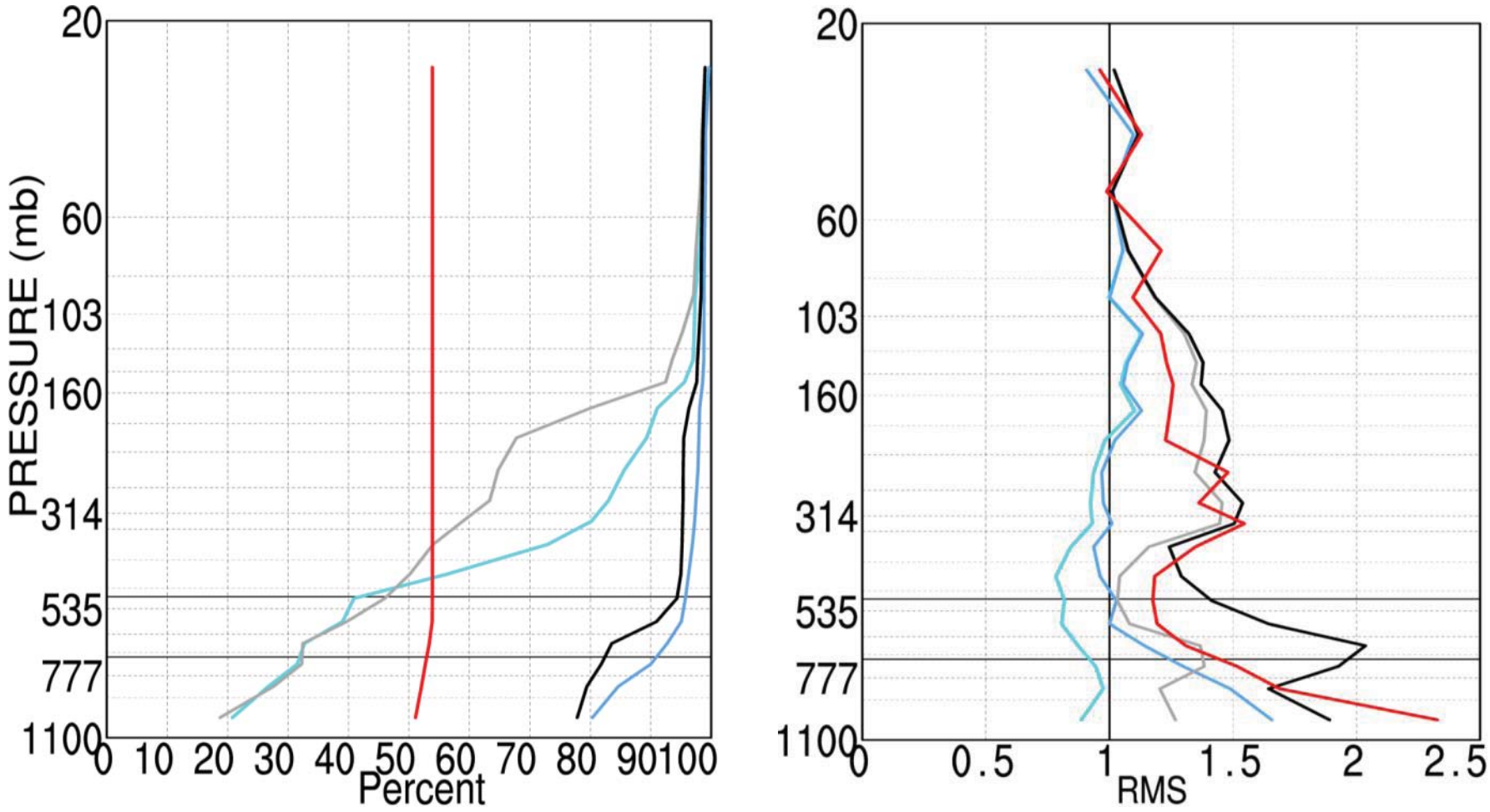


AIRS using DA QC has errors less than 1K in troposphere.
AIRS using Climate QC has 80% yield at surface and 95% yield at 500 mb.
CrIS results are poorer than AIRS – should improve with Neural-Net guess.

Global Temperature Profile December 4, 2013

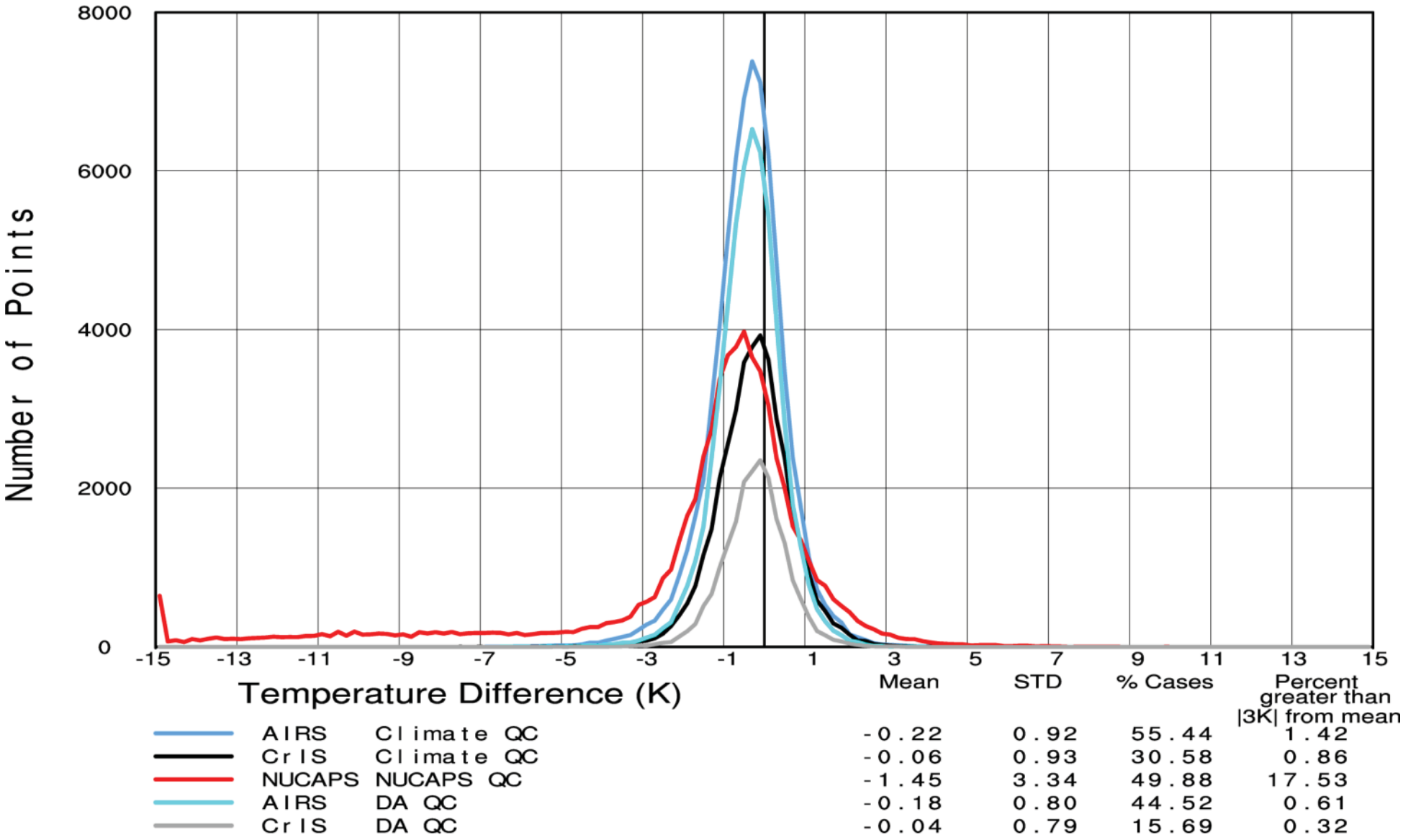
Percent of All Cases Accepted

RMS 1 km Layer Mean
Difference (K) from ECMWF



NUCAPS single QC flag accepts 54% of all cases. Yield is different at the surface because of elevated terrain. NUCAPS accuracy is similar to CrIS with Climate QC, but with much lower yield.

Surface Skin Temperature Difference from ECMWF (K)
December 4, 2013 Daytime and Nighttime
50°N to 50°S Non-Frozen Ocean

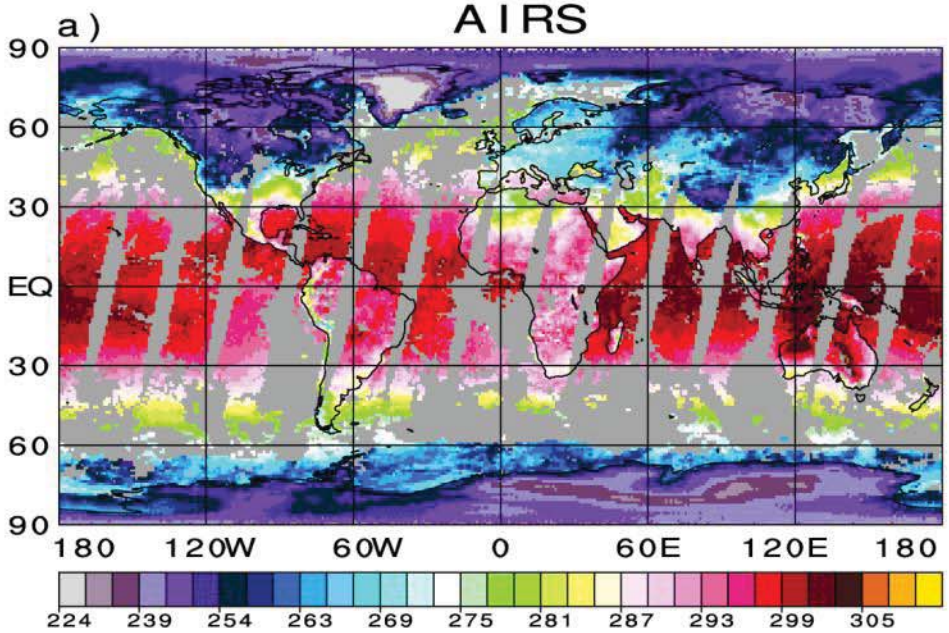


		Mean	STD	% Cases	Percent greater than |3K| from mean
AIRS	Climate QC	-0.22	0.92	55.44	1.42
CrIS	Climate QC	-0.06	0.93	30.58	0.86
NUCAPS	NUCAPS QC	-1.45	3.34	49.88	17.53
AIRS	DA QC	-0.18	0.80	44.52	0.61
CrIS	DA QC	-0.04	0.79	15.69	0.32

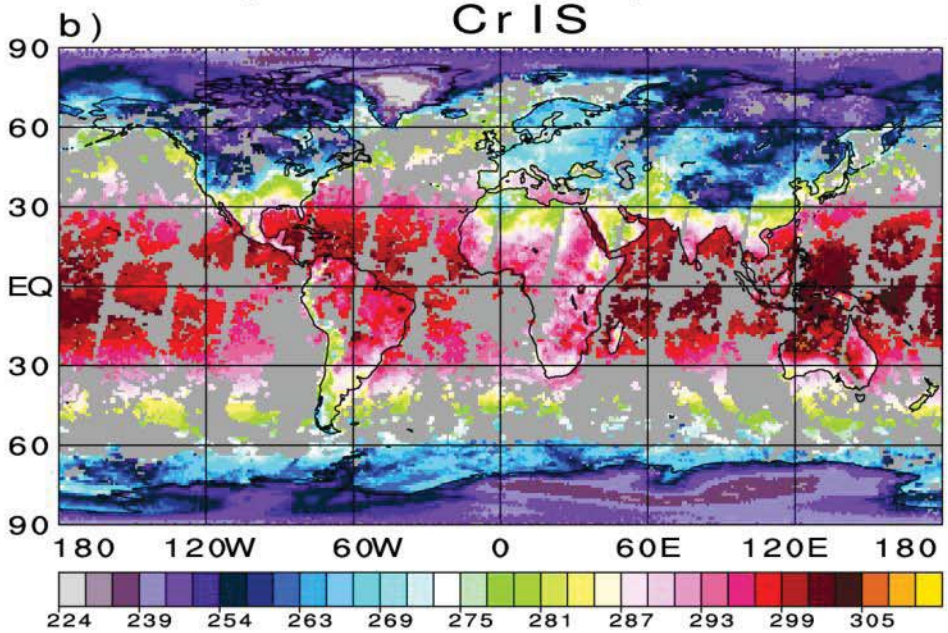
Single NUCAPS QC flag accepts ≈ 50% of ocean cases, but many are poor retrievals.

AIRS with Climate QC accepts more cases, with very high accuracy.

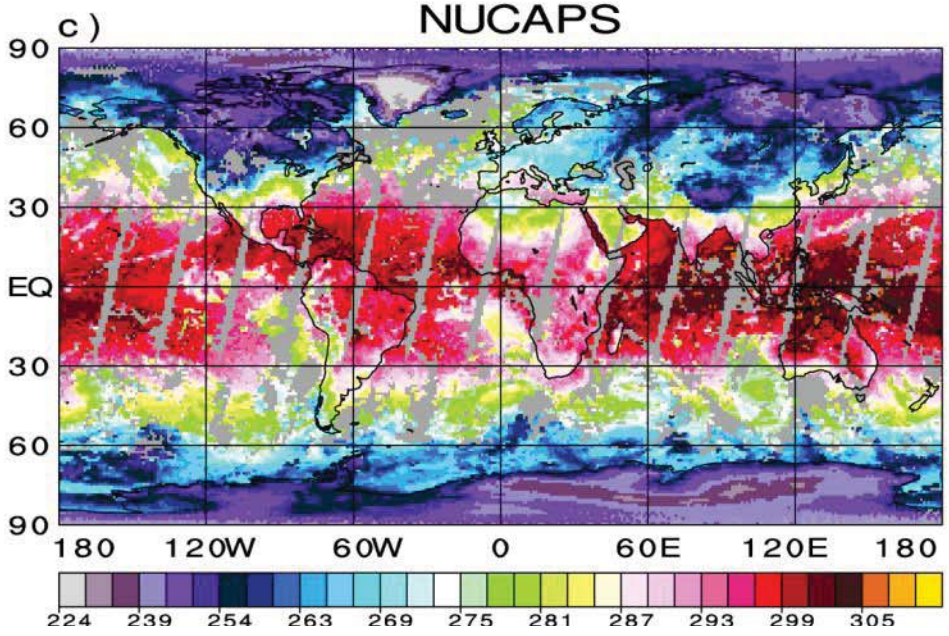
December 4, 2013 Surface Skin Temperature(K) 1:30 AM



Global Mean= 282.98 STD= 15.96 %Fill 67.43



Global Mean= 282.85 STD= 15.55 %Fill 65.76



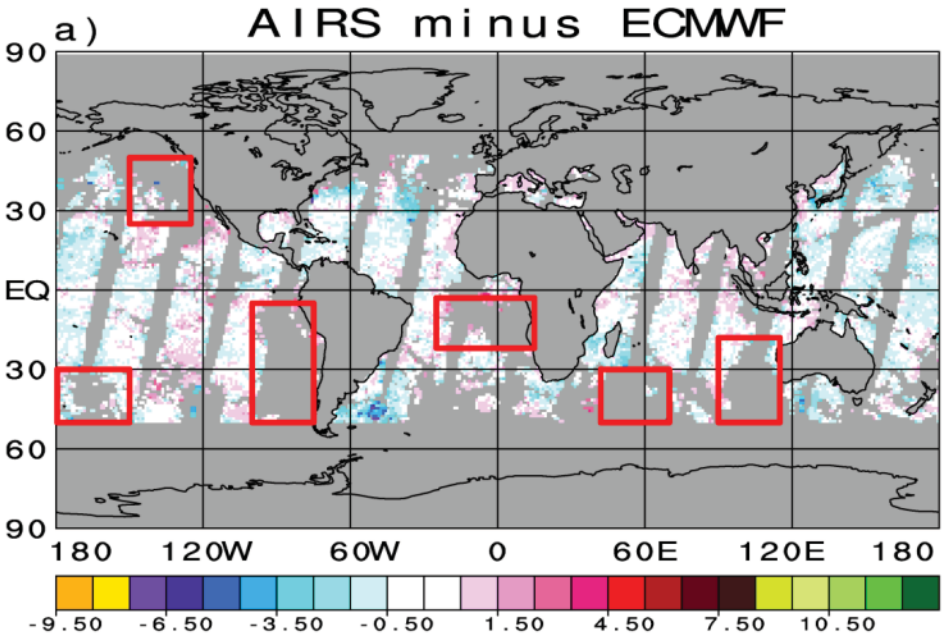
Global Mean= 282.64 STD= 15.02 %Fill 81.20

All level-3 Tskin fields have good land spatial coverage

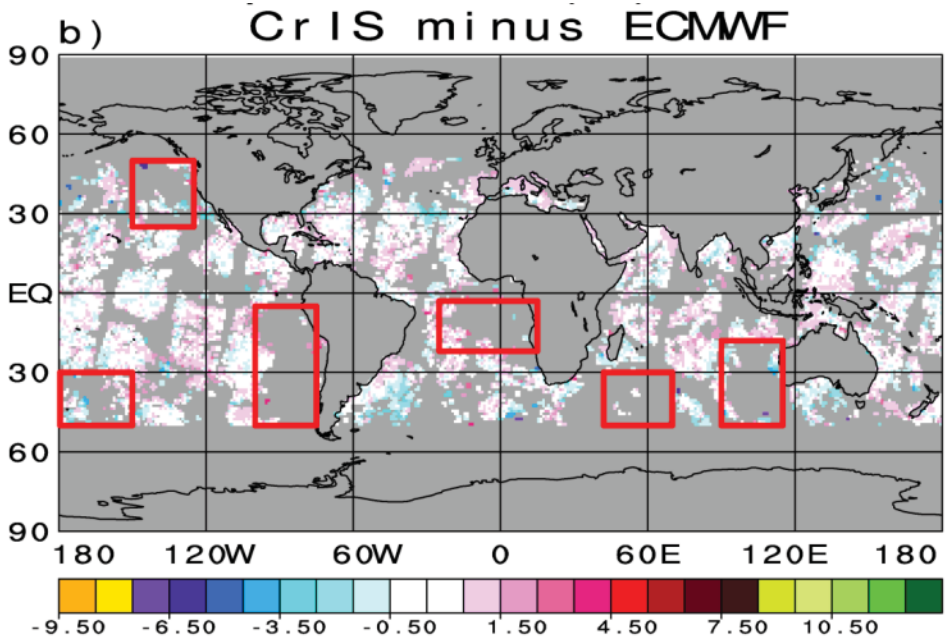
AIRS Ocean Tskin spatial coverage is better than CrIS. Both have large gaps in similar places.

NUCAPS Ocean Tskin spatial coverage is almost complete. This is not necessarily a good result.

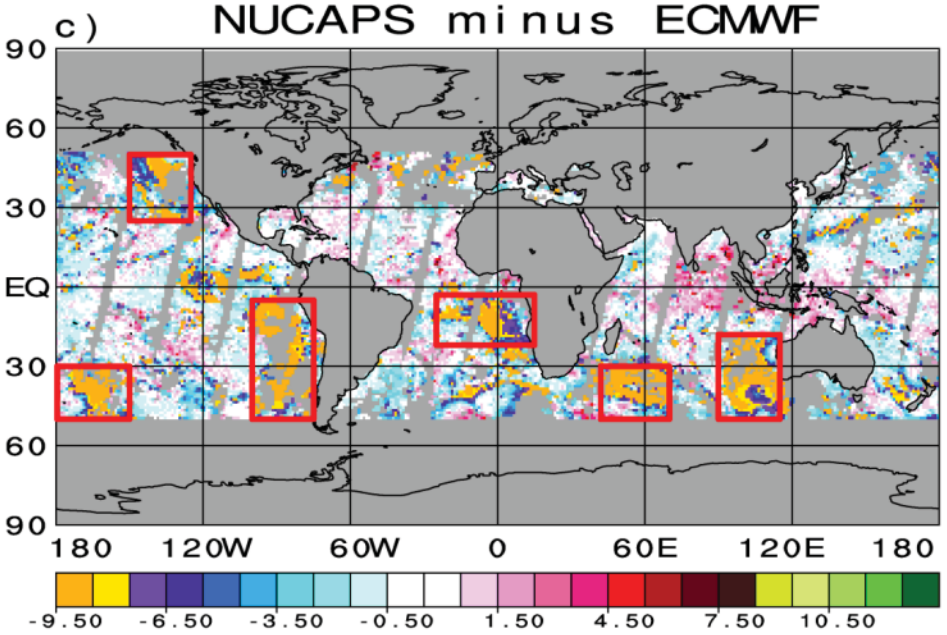
December 4, 2013 Ocean Skin Temperature(K) 50°N to 50°S 1:30 AM/PM Average



Global Mean= -0.27 STD= 0.93 Corr= 0.99



Global Mean= 0.10 STD= 0.92 Corr= 0.99



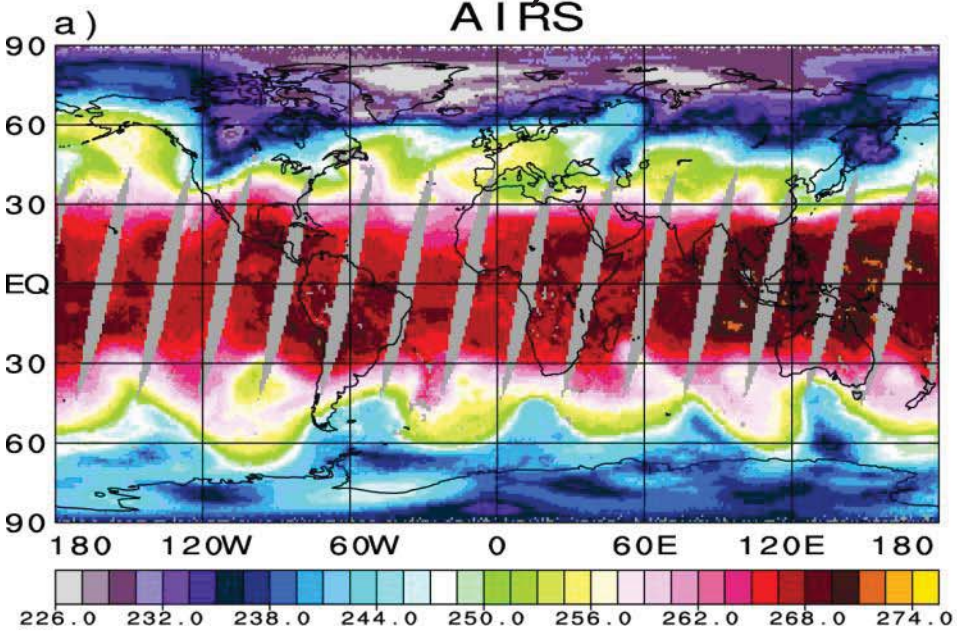
Global Mean= -2.13 STD= 4.07 Corr= 0.91

AIRS has comparable accuracy to CrIS with better spatial coverage

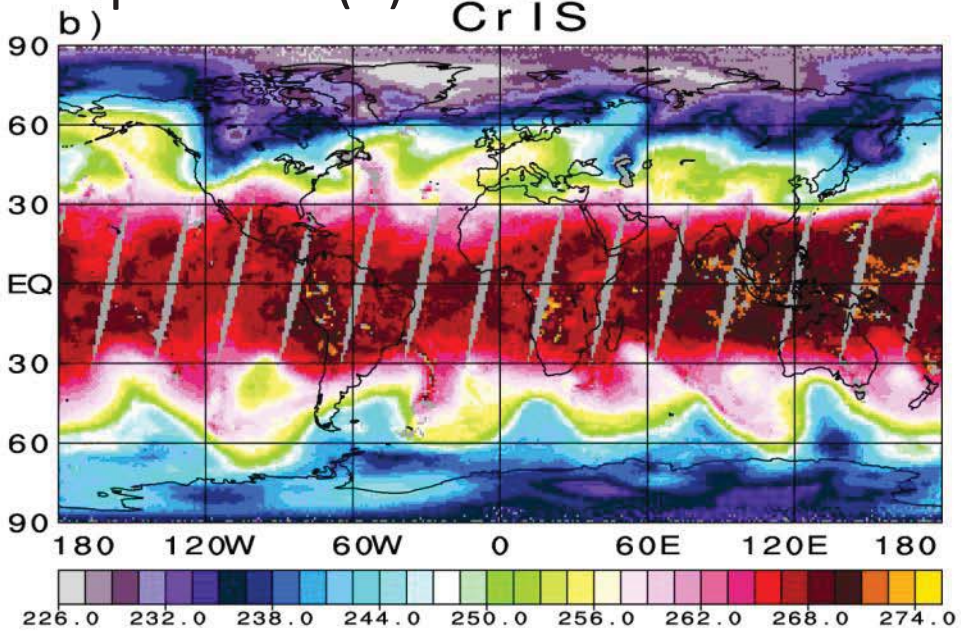
Red boxes indicate sample areas covered by NUCAPS by not AIRS or CrIS

NUCAPS Tskin is considerably too cold in these areas

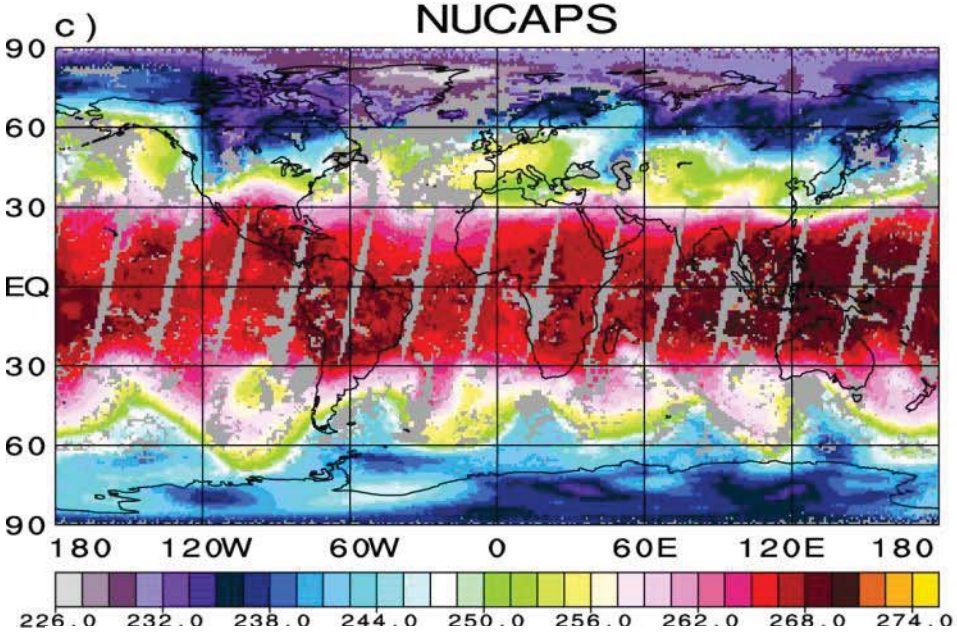
December 4, 2013 500 mb Temperature(K) 1:30 AM



Global Mean= 256.61 STD= 10.60 %Fill 88.38



Global Mean= 257.45 STD= 10.38 %Fill 94.55



Global Mean= 257.60 STD= 9.90 %Fill 81.20

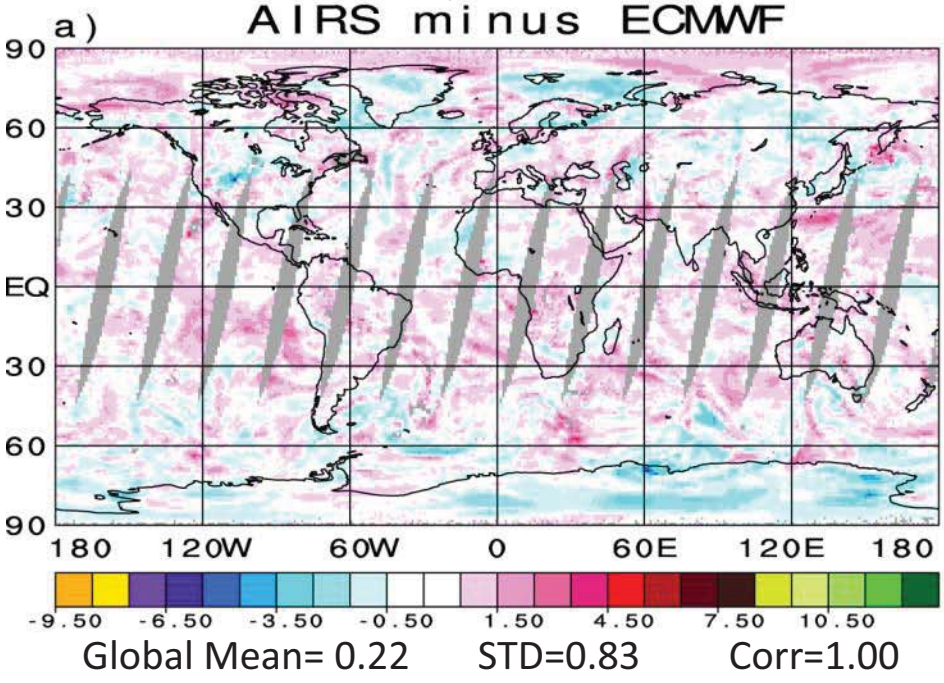
AIRS and CrIS level-3 500 mb temperature fields have almost complete spatial coverage

CrIS covers more grid points because orbit gaps are smaller

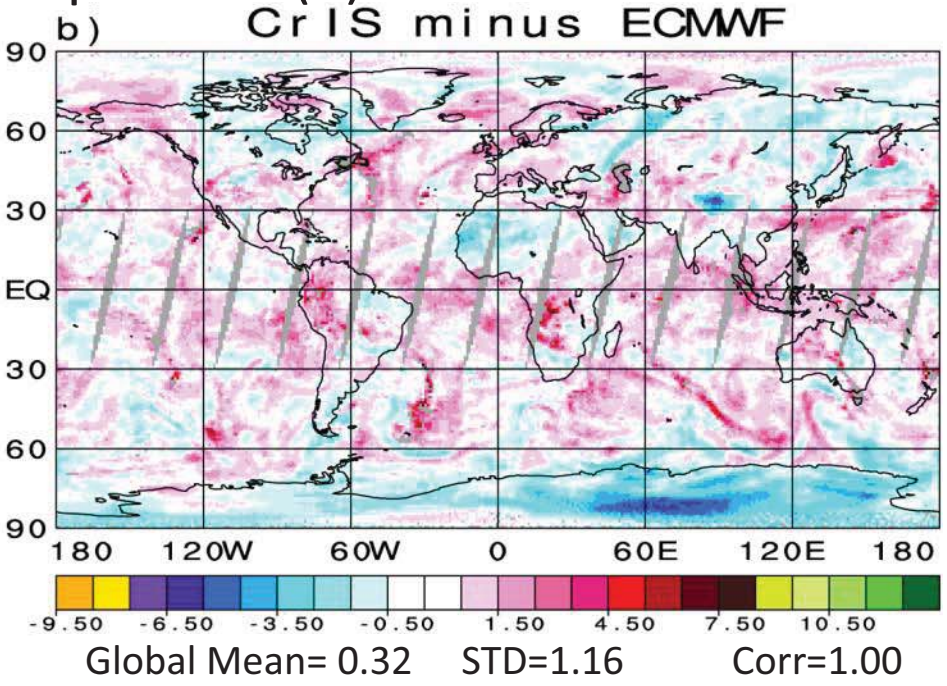
NUCAPS 500 mb temperature spatial coverage is identical to that of Tskin

NUCAPS has gaps at leading edges of cold fronts

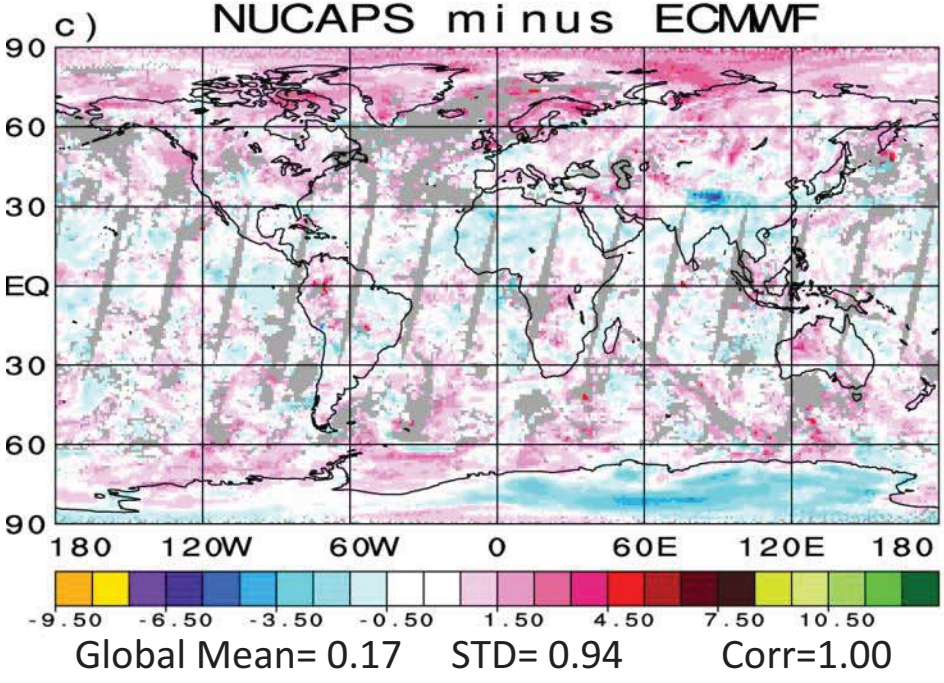
December 4, 2013 500 mb Temperature(K) 1:30 AM



Global Mean= 0.22 STD=0.83 Corr=1.00



Global Mean= 0.32 STD=1.16 Corr=1.00



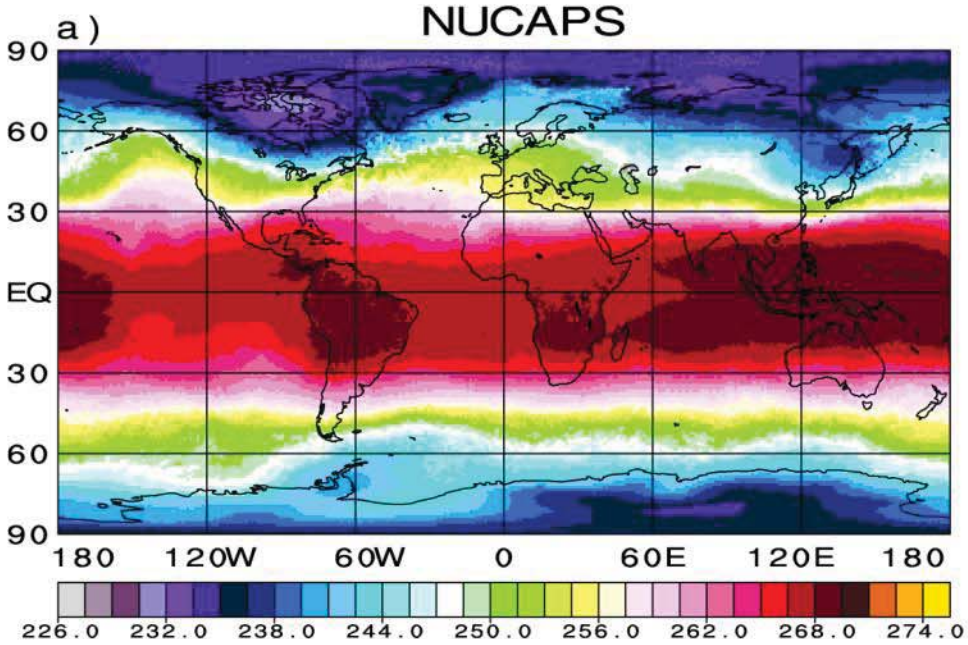
Global Mean= 0.17 STD= 0.94 Corr=1.00

NUCAPS 500 mb temperature "accuracy" is poorer than AIRS but better than CrIS

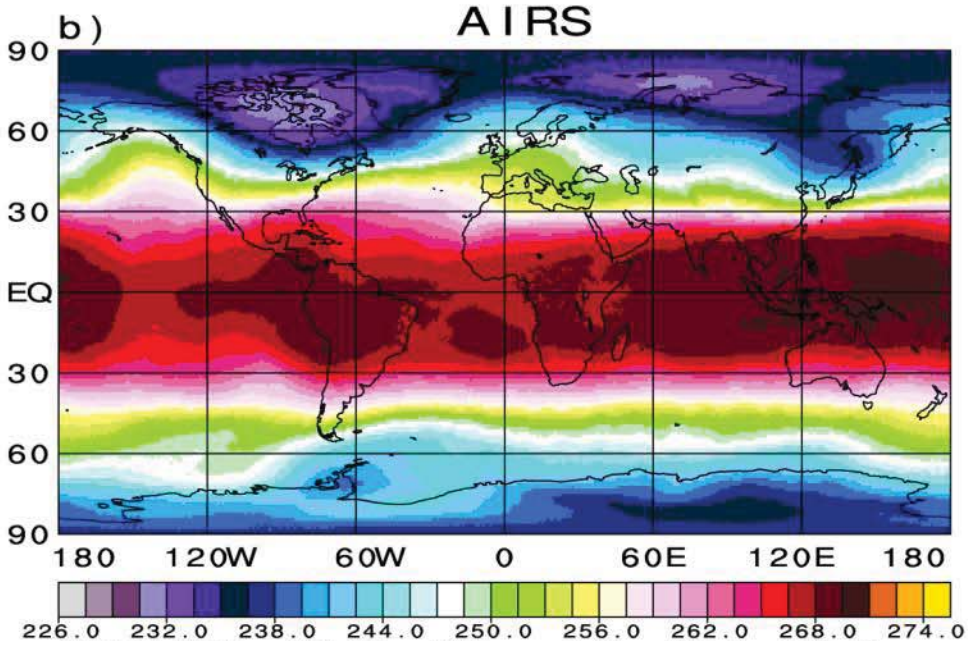
This does not tell the whole story

NUCAPS systematic rejection of leading edges of cold fronts leads to spuriously warm monthly mean temperatures

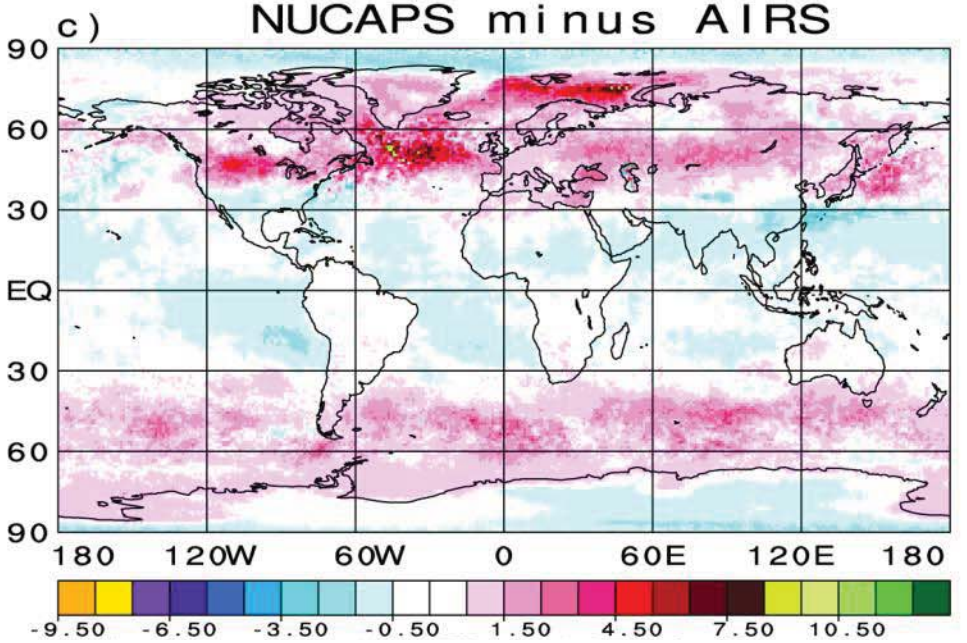
December 2013 Monthly Mean 500 mb Temperature(K) 1:30 AM/PM Average



Global Mean= 258.24 STD= 9.26 %Fill 99.97



Global Mean= 258.04 STD= 9.88 %Fill 100.00

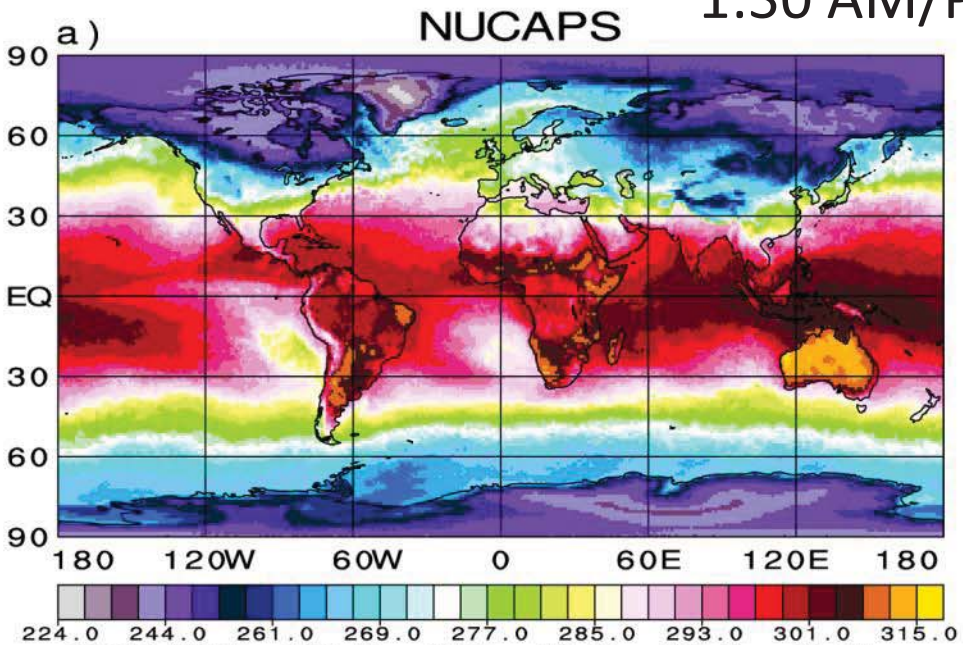


Global Mean= 0.20 STD= 0.97 Corr = 1.00

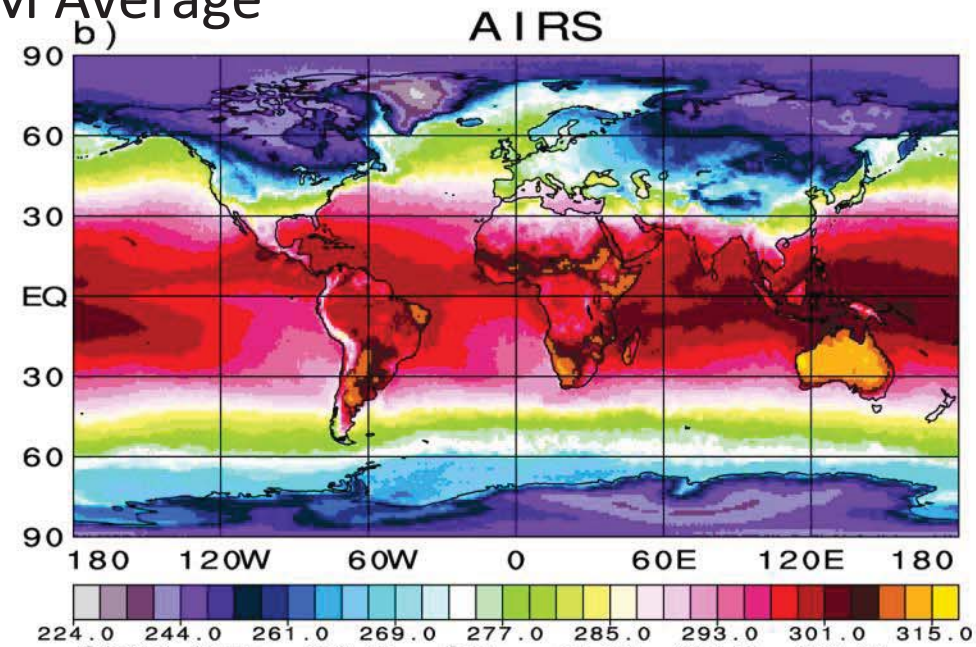
AIRS monthly mean level-3 500 mb temperature is much smoother than NUCAPS at high latitudes because NUCAPS has daily gaps at leading edges of cold fronts.

NUCAPS monthly mean 500 mb temperature is spuriously warm, as compared to AIRS in areas where moving cold front locations were systematically excluded from the monthly mean product.

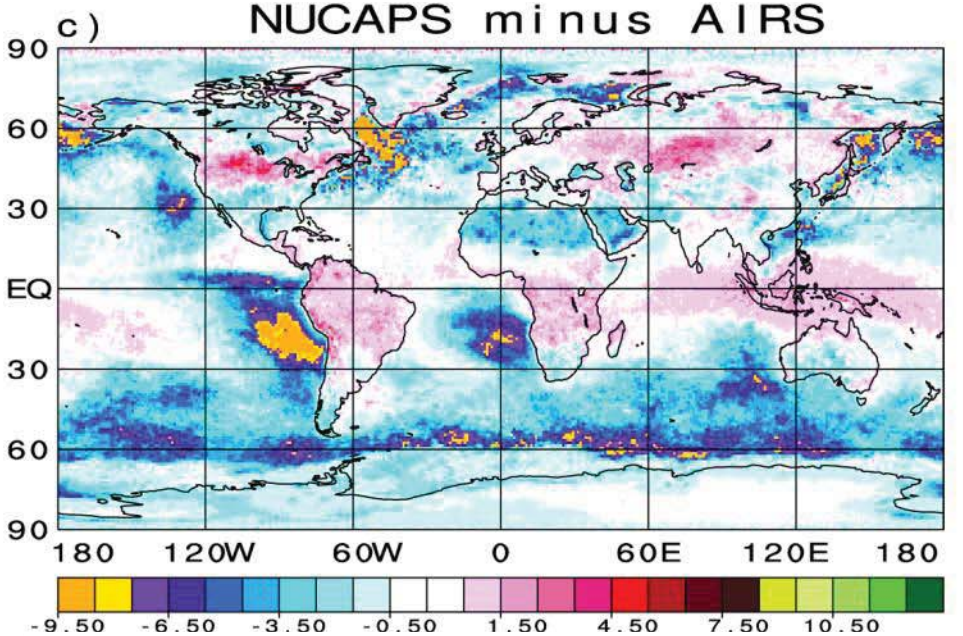
December 2013 Monthly Mean Surface Skin Temperature(K)
1:30 AM/PM Average



Global Mean= 285.43 STD= 14.49 %Fill 99.97



Global Mean= 286.73 STD= 14.00 %Fill 100.00



Global Mean= -1.30 STD= 2.17 Corr = 0.99

NUCAPS level-3 monthly mean sea surface temperatures are spuriously very cold compared to AIRS in areas containing large amounts of cloud cover. This is primarily the result of the single NUCAPS QC flag accepting very poor cases on a daily basis.

There are also significant differences in NUCAPS land surface temperatures as compared to AIRS. This is not necessarily the result of poor QC.

Summary and Plans

- Version 5.70 CrIS/ATMS *T(p)* and T_s retrievals are poorer quality than AIRS/AMSU, especially for T_s. This could be a result of the CrIS shortwave spectral coverage which is truncated at 2550 cm^{-1}. Version-5.70 CrIS/ATMS is now implemented and tested at the JPL Sounder PEATE. We plan to generate Version-5.70 CrIS/ATMS monthly mean level-3 products for a number of months and compare with those of AIRS.
- We want to work with Antonia Gambacorta and co-workers to implement NUCAPS product dependent QC flags. The current NUCAPS product independent QC flags eliminates important cases for *T(p)* and allows bad cases for T_s. We will test these by generating new monthly mean NUCAPS level-3 products and comparing them with AIRS and CrIS 5.70.
- We will begin testing and optimizing CrIS/ATMS Version 6 once the CrIS/ATMS Neural-Net first guess is operating at SRT and then implement and test this system at JPL for a number of months, if not years. We will compare monthly mean inter-month and interannual differences obtained from AIRS, CrIS, and NUCAPS.

High Spectral Resolution CrIS Data

NOAA plans to begin to downlink the full interferogram for all CrIS bands in the future.

Three Issues

- We need a new high spectral resolution CrIS RTA to analyze this data

  Preferably consistent with our current RTA provided by

  Larrabee Strow – must include non-LTE.
- From the long term CrIS CDR perspective, this might introduce a discontinuity in level-3 retrieval products. It might be better to generate long term level-3 CDR products using consistent spectral resolution CrIS data.
- Given this consideration, it would be important to generate two sets of CrIS SDR's: low spectral resolution as before and high spectral resolution.


NASA